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The gastrointestinal nematodes of *Varanus rosenbergi* (Reptilia: Varanidae) and the effects of habitat change in southern Australia, with particular reference to the genus *Abbreviata* (Physalopteroidea)

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Abstract – Nine species of nematode were collected from the stomachs of 56 *Varanus rosenbergi* from southern Australia, viz. *Abbreviata anomala, A. antarctica, A. confusa, A. hastaspicula, A. levicauda, A. tumidocapitis, Pseudorictularia disparilis, Maxvachonia chabaudi,* and *Ophidascaris pyrrhus*. *A. antarctica* occurred in 93% of lizards. Sixty-two percent of lizards were infected with this species only, and 30% had concurrent infections with from two to five species of *Abbreviata*. *A. levicauda* and *A. hastaspicula* were present at low prevalence in the drier and hotter parts of this host's range. Intensity of infection with *Abbreviata* nematodes ranged to more than 400 adults, and more than 600 *Abbreviata* spp. larvae. Highest intensity of infection with *A. antarctica* in Western Australia was east of the agricultural areas, and in or close to reserves where the ecosystem was less disturbed. The high prevalence of nematodes in this genus across a wide range of habitat and climate types suggests a prevalent arthropod intermediate host, or a wide range of species of arthropod, which are susceptible to infection.

Key words: *Varanus rosenbergi, Abbreviata* nematodes, habitat change, Australia.

INTRODUCTION

Varanus rosenbergi Mertens, 1957 was recognised as a subspecies of *Varanus gouldii* by Mertens (1957), and was elevated to species status by Storr (1980). It is a large predatory diurnal monitor lizard which occurs in a wide range of habitats in southern Australia south of latitude 30° S, principally in Western Australia and South Australia, with isolated populations in Victoria and New South Wales (Cogger 1992). Several studies have shown that nematodes in the genus *Abbreviata* predominate in *Varanus* lizards in Australia, frequently reaching high intensity and prevalence in larger species (Jones 1983a, 1983b, 1985, 1988). Apart from *V. varius* in southern Victoria, *V. rosenbergi* occurs further south than any other species of *Varanus*. Its range across a number of ecosystems in this southern distribution may throw light on factors which delimit the distribution of its parasites. The present study was therefore undertaken to determine which nematode species *V. rosenbergi* supported, their prevalence, intensity and geographical range, and to examine the external environmental factors which might influence the worms' occurrence in this host.

MATERIALS AND METHODS

Nematodes were recovered from 56 *Varanus rosenbergi* preserved in the Western Australian Museum (n: 48), the South Australian Museum (n: 4), CSIRO Sustainable Ecosystems, Canberra (n: 3), and one in a private collection. Forty-eight lizards were from Western Australia, seven from South Australia (five of which were collected on Kangaroo Island), and one from the Australian Capital Territory. This study includes findings from 7 previously reported host specimens (Jones 1983a). All worms were cleaned, cleared in chlorolactophenol for examination, and stored in 70% ethanol with 10% glycerine. Specimens have been deposited in the Western Australian Museum, South Australian Museum and CSIRO Sustainable Ecosystems, Canberra. Landsat images provided by the Western Australian Department of Land Information were used to compare nematode occurrence with surface vegetation cover, and meteorological maps were consulted on the Bureau of Meteorology website (www.bom.gov.au).

RESULTS

Nematodes recovered. Nine species of nematode were recovered: *Abbreviata anomala, A. antarctica, A. confusa, A. hastaspicula, A. levicauda, A. tumidocapitis, Pseudorictularia disparilis,* (Spirurata: Physalopteridae), *Maxvachonia chabaudi* (Oxyurata: Cosmocercidae) and *Ophidascaris pyrrhus* (Ascaridida: Ascarididae).

Prevalence and intensity (Table 1). The

Table 1 Adult nematodes recovered from 56 *V. rosenbergi*

	No. of lizards infected	prevalence	intensity (mean, range and SD)
Abbreviata anomala	1	1.8%	9
Abbreviata antarctica	52	92.8%	57 (1-341; 67.1)
Abbreviata confusa	2	3.6%	6 (4-8)
Abbreviata hastaspicula	9	16.1%	14 (10-19; 5.7)
Abbreviata levicauda	8	14.3%	28 (1-68; 24.8)
Abbreviata tumidocapitis	14	25.0%	6.5 (1-73; 18.8)
Pseudorictularia disparilis	1	1.8%	1
Maxvachonia chabaudi	1	1.8%	1
Ophidascaris pyrrhus	1	1.8%	2

predominant species was *A. antarctica*, which was recovered from 93% of lizards. It occurred in 46/48 hosts from Western Australia, (the remaining two lizards having *Abbreviata* spp. larvae only), in numbers ranging from one to 341 per host; the only two lizards without infection of either adult or larval *Abbreviata* spp. were from mainland South Australia and from Kangaroo Island. Sixty-one percent also had larval or immature *Abbreviata* spp. in the stomach lumen, not referable to species, in numbers from 1–606. No larval cysts were seen in the stomach or peritoneal tissues. *A. tumidocapitis* occurred in 14 hosts, *A. hastaspicula* in nine hosts, and *A. levicauda* in eight hosts; these three species were present at lower mean intensity than *A. antarctica*. *A. confusa* was present in two hosts, and *A. anomala*, *P. disparilis*, *M. chabaudi*, and *O. pyrrhus* were each recovered from one host.

Concurrent infections (Table 2). Sixty-two percent of lizards supported a single gastric nematode species, *A. antarctica*. Apart from one *A. confusa*, all eight other nematode species occurred concurrently with *A. antarctica*. Thirty percent supported two or more species. Twelve out of fourteen *A. tumidocapitis* infections also occurred concurrently with *A. hastaspicula* and/or *A. levicauda*, and they were usually present when other worms were at high intensity. All nine infections with *A. hastaspicula* and all eight infections with *A. levicauda* occurred concurrently with one another, and/or with *A. tumidocapitis*. Although there was no correlation between intensity of *A. antarctica* and intensity of infection with other species ($p>0.1$), the mean intensity of adult *A. antarctica* was higher when there was concurrent infection with one to four other species of *Abbreviata* (80.5 worms; SD 101.3; N:14) than in single-species infections (37.2 worms; SD 39.4; N:31; $p = 0.028$) The mean

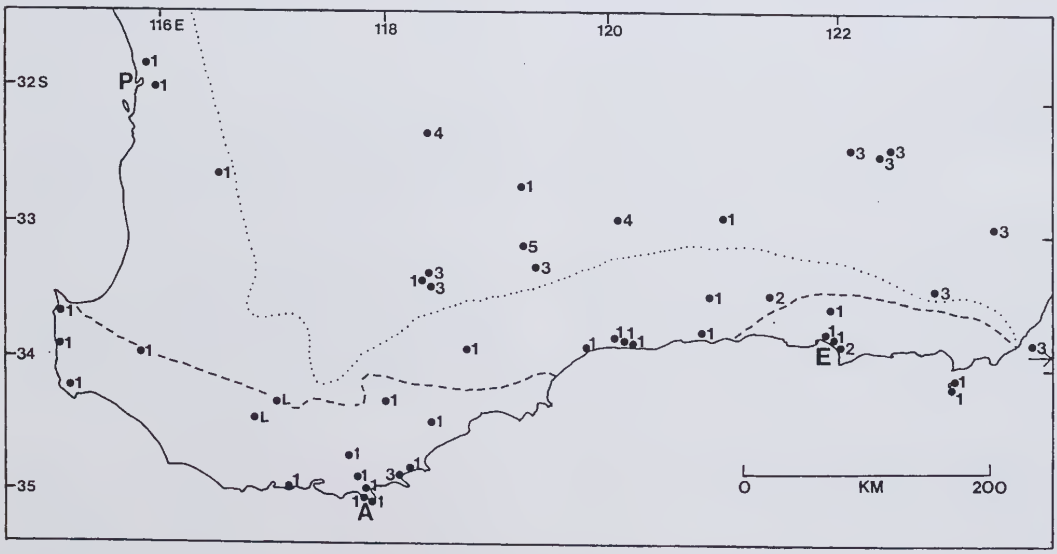

Figure 1 Number of concurrent species of *Abbreviata* occurring in *Varanus rosenbergi* in Western Australia. (L, larval *Abbreviata* sp. only). The specimen east of the area of the map refers to a lizard at Eucla. The area north of the dotted line has an average annual precipitation of <400mm; the dashed line shows the February mean maximum 24°C isotherm. (P: Perth, A: Albany, E, Esperance).

Table 2 Number of species of *Abbreviata* nematode per host

no. of lizards	no. of nematode species
2	0
37*	1
3	2
10	3
2	4
1	5

* includes two lizards with larval *Abbreviata* sp. only

number of all adult *Abbreviata* species in mixed infections was 109.6, (N: 13).

Geographical distribution. Three species of *Abbreviata*, *A. hastaspicula*, *A. levicauda* and *A. tumidocapitis*, were with one exception absent from the relatively cooler and more humid south-west of Western Australia, occurring principally in the northern parts of the range of *V. rosenbergi*. *A. levicauda* and *A. hastaspicula* occurred inland, in areas with an average annual rainfall of less than 400mm and a mean maximum February temperature in excess of 24°C, Figure 1. *A. tumidocapitis* had a similar distribution, although there were three records near the south coast. The two *A. confusa* records were from Kangaroo Island, South Australia, and near Queanbean in the Australian Capital Territory.

A. antarctica occurred throughout the range of *V. rosenbergi*. Intensity was significantly higher in lizards collected in eastern Western Australia, east of latitude 119°E, where in general the vegetation was less disturbed, Figure 2. Lizards from reserves in or west of the Wheatbelt (Cape Naturaliste NP, Stirling Range NP, Lake Magenta NR, Pallarup and Dunn Rocks NR and Dragon Rocks NR) contained 45–341 worms per host (N: 6, mean 138). Lizards collected from around the cities of Perth and Albany and from the intensively cleared areas of the Wheatbelt supported lighter infections, with from one to 24 worms per host (N: 18, mean 9.4).

DISCUSSION

Varanus rosenbergi supports a considerable gastric nematode fauna throughout its geographical range. Four species of nematode were recovered from one host only, and these were probably accidental infections resulting from ingestion with prey; *Maxvachonia* spp. (Oxyurata) occur in the rectum of several species of skinks, geckos and agamid lizards (Mawson 1972), *A. anomala* is found in agamid lizards in the genus *Pogona* (Jones 1986a), and *O. pyrrhus* in snakes (Jones 1980). *P. disparilis* is probably a parasite of amphibians (Owens and Moorhouse 1980). All other nematodes were in the genus *Abbreviata*. *A. antarctica* has been recorded from many species of larger reptile in eastern, southern and northern Australia, but appears to be absent from the hotter drier inland areas of the continent. Prevalence and intensity are greater in this lizard than in any other reptile host so far recorded. In the hotter and drier inland parts of

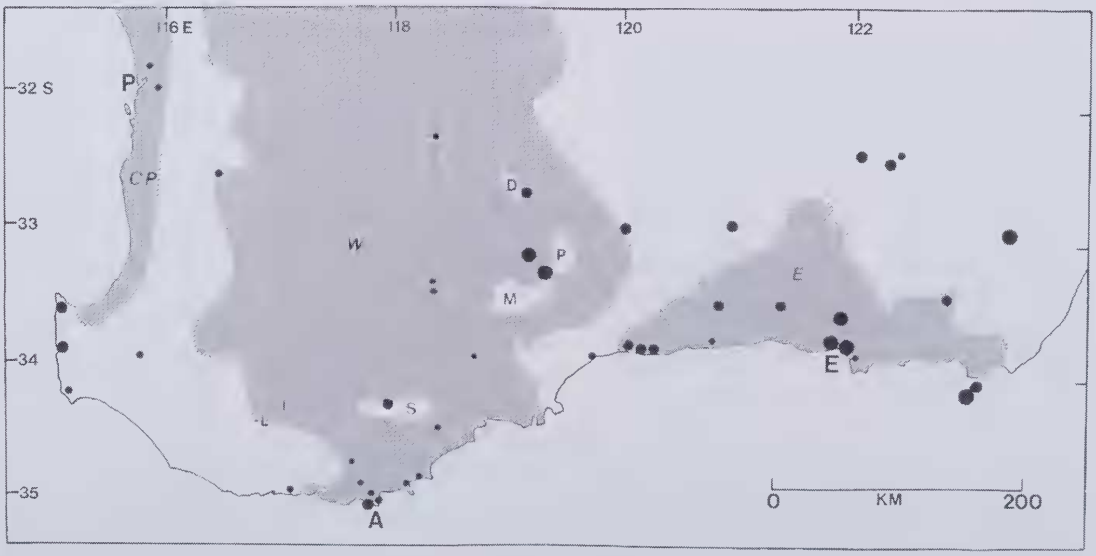

Figure 2 Distribution and intensity of *Abbreviata antarctica* in *Varanus rosenbergi* in Western Australia. • 1–20 adult worms; ● 21–100 adult worms, ● >100 adult worms. L: larval *Abbreviata* only. Areas of major land clearance shaded (taken from satellite images). *CP*, Swan Coastal Plain, *W*, Wheatbelt, *E*. eastern agricultural area. S, Stirling Range National Park; M, Lake Magenta Nature Reserve; P, Pallinup Nature Reserve; D, Dragon Rocks Nature Reserve. P, Perth, A, Albany, E, Esperance.

Western Australia this species is replaced by *A. hastaspicula* and *A. levicauda*; the former attain highest numbers in *V. gouldii* and *V. panoptes* north of the distribution of *V. rosenbergi* (Jones, 1983a), whereas *A. levicauda*, although common in these two host species, occurs predominantly in *V. tristis* (Jones 1986b). These two nematodes were therefore only recovered from the northern areas of the range of *V. rosenbergi*, in low numbers. *A. tumidocapitis* is usually found concurrently with infections of these two species (Jones 1983a). The two records of *A. confusa* were respectively from Kangaroo Island and from the isolated population of *V. rosenbergi* in NSW, near Queanbean. This worm has not been reported from southern Western Australia, though it is found in several species of *Varanus* in the tropical north of this State (Jones 1988).

The intensity of *A. antarctica* infections within the range of *V. rosenbergi* was not directly related either to mean precipitation or to temperature. Numbers were highest east of approximately 119°E, where the vegetation is less disturbed. The only records of high intensity (43 to 329 adult worms) in the Southwest were from, or close to, National Parks or Reserves, suggesting that intensity is reduced by European-induced habitat changes. Nature reserves occupy only 2.4% of the wheatbelt (in 1978), and a study of 23 of these reserves found *V. gouldii* (in which *V. rosenbergi* was included) in only five of these, of which the smallest with *V. gouldii* had an area of 272 hectares (Kitchener et al., 1980). Relatively high numbers were recorded from near the towns of Hopetoun and Esperance, around which there has been extensive land clearance, but both satellite images and direct observation (M. Tonts, pers. comm.) show that this eastern agricultural area contains extensive pockets and strips of residual uncleared land, which could act as refugia for both the lizards and their nematodes' intermediate hosts. The observation that *A. antarctica* numbers were higher in concurrent infections with congeneric species which were near the southern edge of their range than in single-species infections, indicates the complex interplay of climatic and environmental parameters affecting nematode survival and transmission. It is likely that climate has an effect, perhaps indirectly, on survival of nematode eggs, as well as its effect on intermediate hosts. Several biological variables are unknown, including the specificity of the arthropod intermediate hosts required by *A. antarctica*, the prevalence of smaller lizard paratenic hosts, and the density and home ranges of *V. rosenbergi* in different habitats, which can be highly variable (King and Green 1999). *V. rosenbergi* has a varied diet; on Kangaroo Island, arthropods comprise about 35% of the diet by volume, and the majority of vertebrate food is probably obtained from road kills (King and Green 1999). The extent of land clearance in the agricultural areas, clearly shown on satellite images, the habitat perturbation around cities, and the higher vehicle numbers on the roads all have an impact on the ecology of reptile hosts, and therefore on the dynamics of their acquiring infection. Studies on *Abbreviata* spp. in elapid snakes in Western Australia and on *O. pyrrhus* and the trematode *Dolichoperoides macalpini* in *Notechis ater* near Hobart in Tasmania indicate that lower prevalence or absence may be due to altered environments in these urban areas (Jones 1978, 2003). However, records are too sparse from some areas, and collection sites reported are in some cases not sufficiently precise to link habitat to nematode intensity with more confidence.

The significantly higher mean intensity of *A. antarctica* in the presence of concurrent infections with one to four congeneric species reflects the low numbers of *A. antarctica* in the more disturbed ecosystems in the Southwest, from which other species are absent (apart from one anomalous record from Two Peoples Bay east of Albany). *A. antarctica* itself is absent from the drier and hotter areas further north, beyond the range of *V. rosenbergi*. The factors affecting the population dynamics and interspecific relations of these species are not yet understood, but the observations reported here suggest that intensity of *A. antarctica* infection is not adversely affected by competition from other species in this environment. The absence of *A. hastaspicula*, *A. levicauda* and *A. tumidocapitis* in the cooler and more humid areas may be a consequence of the scarcity or absence of suitable intermediate hosts, or by the viability of eggs in the external environment.

CONCLUSIONS

V. rosenbergi is heavily infected with species of *Abbreviata* throughout its range in southern Australia. All but two of the lizards examined were infected, and 26.8% were concurrently infected with three or more species. These results add to previous work in confirming the dominant position of nematodes in the genus *Abbreviata* in the gastric fauna of varanid lizards in arid Australia. The high prevalence across a range of habitat types suggests either that the arthropod intermediate hosts are equally widespread, or that they have a low host-specificity and that many species are involved. However, the lower intensity of *A. antarctica* in those areas where there has been extensive clearing of natural vegetation suggests diminished transmission, and indicates that the nematode parasites are affected by these profound changes to the ecosystem. The patterns of infection in this lizard would be clarified by knowledge of the arthropod intermediate hosts.

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REFERENCES

Cogger, H. G. (1992). Reptiles and Amphibians of Australia. (Reed: Chatsworth, Australia).

Jones, H. I. (1978). *Abbreviata* (Nematoda: Physalopteroidea) from Western Australian snakes. *Australian Journal of Zoology* **26:** 789–807.

Jones, H. I. (1980). Observations on nematodes from west and central Australian snakes. *Australian Journal of Zoology* **28:** 423–433.

Jones, H. I. (1983a). *Abbreviata* (Nematoda: Physalopteroidea) in lizards of the *Varanus gouldii* complex (Varanidae) in Western Australia. *Australian Journal of Zoology* **31:** 285–298.

Jones, H. I. (1983b). Prevalence and intensity of *Abbreviata* Travassos (Nematoda: Physalopteridae) in the Ridge-Tailed Monitor *Varanus acanthurus* Boulenger in northern Australia. *Records of the Western Australian Museum* **11:** 1–9.

Jones, H. I. (1985). Gastrointestinal nematodes of the Perentie, *Varanus giganteus* (Grey), in Western Australia, with description of a new species of *Abbreviata* Travassos (Nematoda: Physalopteridae). *Records of the Western Australian Museum* **12:** 379–387.

Jones, H. I. (1986a). Gastrointestinal nematodes in the lizard genus *Pogona* Storr (Agamidae) in Western Australia. *Australian Journal of Zoology* **34:** 689–705.

Jones, H. I. (1986b). Differences in caudal morphology in male *Abbreviata levicauda* (Nematoda: Physalopteridae) in two sympatric species of Varanus (Reptilia: Varanidae). *Journal of Parasitology* **72:** 185–186.

Jones, H. I. (1988). Nematodes from nine species of *Varanus* (Reptilia) from tropical northern Australia, with particular reference to the genus *Abbreviata* (Physalopteridae). *Australian Journal of Zoology* **36:** 691–708.

Jones, H. I. (2003). Parasitic worms in reptiles from Tasmania and the islands of Bass Strait. *Papers and Proceedings of the Royal Society of Tasmania* **137:** 7–12.

King, D. R. and Green, B. (1999). Goannas. The Biology of Varanid Lizards. University of NSW, 116pp.

Kitchener, D. J., Chapman, A., Dell, J., and Muir, B. G. (1980). Lizard asemblage and reserve size and structure in the Western Australian Wheatbelt – some implications for conservation. *Biological Conservation* **17:** 25–72.

Mawson, P. M. (1972). The nematode genus *Maxvachonia* (Oxyurata: Cosmocercidae) in Australian reptiles and frogs. *Transactions of the Royal Society of South Australia* **96:** 101–113.

Mertens, R. (1957). Ein neuer melanistischer Waran aus dem südlichen Australien (*V. gouldii rosenbergi*, subsp. nov.). *Zoologischer Anzeiger* **159:** 17–20.

Owens, L, and Moorhouse, D. E. (1980). The description of the male *Pseudorictularia disparilis* (Irwin-Smith, 1922) (Nematoda, Physalopteridae) from northern Australia. *Bulletin du Museum nationale d'Histoire naturelle* (4), **2A:** 1013–1017.

Storr, G. M. (1980). The monitor lizards (genus *Varanus* Merrem, 1820) of Western Australia. *Records of the Western Australian Museum* **8:** 237–293.

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